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## Minimum Required Heliport Airspace Under Visual Flight Rules

Advanced System  
Design Service  
Washington, D.C. 20591

AD-A201 433

Robert D. Smith

October 1988

Final Report

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U.S. Department of Transportation  
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## Technical Report Documentation Page

1. Report No. DOT/FAA/DS-88/12 ✓ DOT/FAA/AS-89/1 ✓	2. Government Accession No.	3. Recipient's Catalog No.	
4. Title and Subtitle  Minimum Required Heliport Airspace Under Visual Flight Rules	5. Report Date October 1988		
	6. Performing Organization Code		
	8. Performing Organization Report No.		
7. Author(s) Robert D. Smith	10. Work Unit No. (TRAIS)		
9. Performing Organization Name and Address Federal Aviation Administration Advanced System Design Service Rotorcraft Technology ADS-220 Washington, D.C. 20591	11. Contract or Grant No.		
	13. Type of Report and Period Covered  Final Report		
	14. Sponsoring Agency Code		
15. Supplementary Notes			
16. Abstract <p>Recently, the FAA started a flight measurement project to examine the issue of minimum required VFR airspace. Test data were collected objectively in a manner similar to what is done to define the minimum airspace for a precision approach. Heliport approach and departure flight profiles were recorded using a variety of subject pilots flying several different helicopters. Data were analyzed statistically to determine the mean, standard deviation, and 6 sigma isoprobability curves. Results of this effort are documented in FAA report FAA/CT-TN87/40, <u>Heliport Visual Approach and Departure Airspace Tests</u>. An analysis of the statistical distribution of these data is contained in FAA/CT-TN88/44, <u>Analysis of Distributions of VFR Heliport Data</u>. These test reports are not likely to be the last word on this topic but they should serve to focus the discussion on specific issues in a way that is constructive. This report is intended to focus discussion on how the data should be interpreted, some of the historical issues involved, and the direction to be taken in future work.</p>			
17. Key Words Heliport Design Approach/Departure Airspace Target Level of Safety Collision Risk Model		18. Distribution Statement  This document is available to the public through the National Technical Information Service, Springfield, Virginia 22161.	
19. Security Classif. (of this report)  Unclassified	20. Security Classif. (of this page)  Unclassified	21. No. of Pages  24	22. Price

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## 1.0 BACKGROUND

For visual flight rules (VFR) heliports, approach and departure surfaces are described in Federal Aviation Administration (FAA) Advisory Circular 150/5390-2, Heliport Design<sup>1</sup>. Since these surfaces constitute the minimum required airspace for a heliport, they have been the subject of debate for many years. During the recent revision of this advisory circular, the level of debate has intensified.

On this topic, the spectrum of views can be defined by describing the opinions that are furthest apart. Some in industry have argued that pilots use far less airspace than the current minimum required VFR heliport airspace. (This point is argued more vigorously regarding newer helicopters which have considerably higher power to weight ratios.) Some in the FAA have responded that they have not seen a body of data that confirms that the current minimum required VFR heliport airspace is adequate. With a close reading, these views are not necessarily in opposition. The missing entities, however, are measured data and a consensus on how to treat those data.

Recently, the FAA started a flight measurement project to examine the issue of minimum required VFR airspace. Test data were collected objectively in a manner similar to what is done to define the minimum airspace for a precision approach. Heliport approach and departure flight profiles were recorded using a variety of subject pilots flying several different helicopters. Data were analyzed statistically to determine the mean, standard deviation, and 6 sigma isoprobability curves. Results of this effort are documented in FAA report FAA/CT-TN87/40, Heliport Visual Approach and Departure Airspace Tests. An analysis of the statistical distribution of these data is contained in FAA/CT-TN88/44, Analysis of Distributions of VFR Heliport Data. These test reports are not likely to be the last word on this topic but they should serve to focus the discussion on specific issues in a way that is constructive.

## 2.0 OBJECTIVE

This report is intended to focus discussion on how the data should be interpreted, some of the historical issues involved, and the direction to be taken in future work.

Among the many questions of interest in this discussion are the following:

What is the history behind the minimum VFR heliport airspace currently required?

Precision and nonprecision approaches/departures have some elements of commonality with VFR approaches/departures. What are these commonalities? Do they shed any light on how to analyze the VFR heliport flight data?

If the rotorcraft community is to consider changing this minimum required VFR heliport airspace, what considerations are involved? On what basis should we judge any proposed modification?

What conclusions can we make from the testing and analysis done to date? What additional work is necessary to bring this issue to a definitive conclusion?

### 3.0 MINIMUM VFR HELIPORT AIRSPACE

#### 3.1 Historical Perspective

The VFR heliport surfaces are not based on a body of measured data. Rather, they are based on operational judgment. The author has not uncovered any document which provides the detailed rationale for the judgments made in the development of the current requirements.

For VFR heliports, approach and departure surfaces are defined by Federal Aviation Regulations (FAR) Part 77 Subpart C (paragraph 77.29). These same surfaces are included in FAA Advisory Circular (AC) 150/5390-2, Heliport Design dated 4 January 1988. The surfaces in AC 150/5390-2 are not different from the surfaces in the previous AC 150/5390-1, Heliport Design Guide dated 22 August 1977. However, in 1962 and again in 1965, significant changes were made to the heliport surfaces defined in the FARs. In both cases, these changes lead to dramatic reductions in the size of the minimum heliport airspace. (See Appendix D for the prior FAR 77 and FAR 626 definitions of the heliport surfaces. (FAR 626 was the precursor to FAR 77.))

FAR Part 77 is entitled "Objects Affecting Navigable Airspace". Among other things, Part 77 does the following:

- establishes standards for determining what constitutes an obstruction to navigable airspace,

- sets forth requirements for notice to the Administrator of certain proposed construction or alteration, and

- provides for public hearings on the hazardous effect of proposed construction or alteration on navigable airspace.

FAR Part 77 is the cutting edge between aviation and non-aviation interests. It provides the legal basis under which the FAA determines whether an object constitutes a hazard to air navigation. In so doing, the FAA is attempting to protect navigable airspace including that airspace required for approaches to and departures from public VFR heliports. This protection is limited to a determination of hazard. There is no guarantee that a hazard determination will be respected by those who decide whether the particular construction or alteration will be permitted.

FAR Part 77 can have a direct impact on non-aviation interests throughout the United States. As a consequence, Part 77 is one of the more controversial parts of the FAR's. Changing any FAR is typically difficult and time consuming. In the past, changes to FAR 77.29 have not been difficult because they reduced the size of the airspace and because the change was supported by aviation interests. However, changes which would increase the size of the airspace would be difficult to make, even with overriding evidence in support, since the non-aviation interests could be expected to mount a vigorous opposition. Any reduction in the minimum VFR heliport airspace is likely to be permanent.

Even within the rotorcraft community alone, Part 77 is a double-edged sword. If the Subpart 77.29 airspace could be decreased, it would make it easier and less expensive to develop heliports in urban areas. At the same time, however, at all public heliports, it would lessen the amount of heliport airspace that would come under the limited protection provided by FAR 77. (Neither private heliports nor private airports have any protection under FAR 77.)

### 3.2 Multiple Obstructions

As a part of this discussion, one should recognize that there is no heliport that just meets the minimum airspace requirement. No existing heliport has a multitude of obstacles just below the approach surface and just outside both sides of the approach path (the so called "picket fence"). Were a heliport built in such a location, it is likely that many pilots would find it unacceptable. As more heliports are built in urban areas, the issue of multiple obstacles is one that more regularly will be of concern. For a variety of reasons, this problem can not be solved by simply increasing the size of the minimum required VFR heliport airspace. The issue is not whether one single obstacle presents a hazard. Rather, it is the matter of determining when a plethora of obstacles just outside the minimum required airspace would present a hazard during a VFR approach or departure. To date, no rigorous testing has been done on this issue and no existing methodology describes how such a determination would be made. FAR Part 77 provides no protection against this possibility.

Developing a methodology to make this determination would be a sizable undertaking. In the absence of such an agreed upon methodology, however, this determination will be made on a non-standard basis from region to region and from district office to district office. In addition, such determinations are likely to be made after the last of a group of obstacles has been constructed which makes the heliport unsafe in the opinion of a percentage of the pilots who have been using it. An agreed upon methodology would allow the hazard determination to be considered prior to construction of this last obstacle.

### 3.3 Curved Approaches

With regard to instrument flight rules (IFR) operations, it is well established that straight and level flight operations consume less airspace than curved operations. Analysis of the FAA/CT-TN87/40 test data indicates that this is also true for visual operations at a heliport. AC150/5390-2 recognizes that a heliport approach or departure may be along a curved path. However, the AC does not provide any guidance on how much curvature is allowed, the minimum length of the final straight segment, or the additional width of the primary surface for a curved approach or departure. The results of a mathematical/analytical approach to redefining the minimum VFR heliport airspace will be useful in the initial definition of the minimum airspace required for curved approaches/departures.

### 4.0 MINIMUM NONPRECISION APPROACH HELIPORT AIRSPACE

The current heliport surfaces required to support a nonprecision (no vertical guidance) approach or departure are not based on a body of measured data. Rather, they are based on operational judgment. The author has not uncovered any document which provides the detailed rationale for the judgments made in the development of the current requirements. Thus, if we are to develop a mathematical/analytical method for redefining the minimum airspace required for VFR heliports, the method used to determine the minimum airspace required for a nonprecision approach heliport does not provide a model for our consideration.

None the less, the minimum airspace required for a nonprecision heliport is a matter of concern in our discussion of VFR heliport airspace. Currently, the minimum airspace required for a VFR heliport is the same as that required for a heliport with a nonprecision approach. If the minimum required VFR heliport airspace were reduced, it might allow the establishment of a heliport at locations which do not have sufficient airspace for nonprecision approaches. Thus, these "VFR only heliports" would not be eligible for upgrade to nonprecision approach heliports.

Many years ago, the FAA established standards for "VFR only airports". Several of these "VFR only airports" were built. Afterwards, the owners applied for a change of name and indicated that they intended to apply for a nonprecision approach. The result was that the FAA cancelled the standard which defined "VFR only airports". With this experience in mind, it is open to debate whether the FAA would agree to a "VFR only heliport".<sup>2</sup> Thus, a change in the minimum required VFR heliport airspace must take into account the consequences which flow from a difference between minimum VFR heliport airspace and minimum nonprecision approach heliport airspace. If the minimum required VFR heliport airspace is to be reduced, it would be desirable to analyze critically whether a reduction is possible in the minimum airspace required to support nonprecision approaches to heliports.

## 5.0 OBSTACLE CLEARANCE CRITERIA - PRECISION APPROACHES

### 5.1 Historical Perspective

The minimum airspace required for precision approaches and departures is heavily dependent on obstacle clearance considerations. In the United States, these considerations are codified in terminal instrument approach procedures (TERPS). In the international arena, obstacle clearance criteria were first developed by the International Civil Aviation Organization (ICAO) in 1949. In 1951, they were approved by the ICAO Council for inclusion in the Procedures for Air Navigation Services - Aircraft Operations (PANS-OPS). The first edition of the PANS-OPS was approved by the ICAO Council in June 1961.<sup>3</sup>

In 1966, the ICAO Air Navigation Commission (ANC) recognized that the existing criteria were not geared to modern aircraft in terms of size, speed, and performance.<sup>4</sup> (Note that one facet of the argument put forth by some in the rotorcraft industry is that existing VFR heliport airspace is excessive for modern helicopters due to their vastly improved performance.)

In response, the ANC formed the Obstacle Clearance Panel (OCP) to update these procedures for applications to all types of airplanes taking into account requirements for subsonic multi-jet airplanes and technical developments with respect to navigation aids. At the first meeting in Montreal, January 1968, the OCP agreed to proceed along two lines.<sup>5</sup>

"First, the Panel would endeavor to rationalize the various criteria now in use and those in the several ICAO documents. This process would involve study and analysis of existing criteria and where possible simplification and unification of the various criteria based on the experience and judgment of the Panel's experts."

"Second, the Panel would attempt to develop a more precise and scientifically valid method of developing obstacle clearance criteria. This would be done:

- (a) by collection of data on actual aircraft approaches;
- (b) by study of the characteristics of aircraft systems, of the pilot responses, and of the nature of electronic (and visual) aids to instrument approach; and,
- (c) by mathematical/analytical study of how these factors combine in practice."

The OCP successfully completed both lines of work. As a result of their efforts, ICAO instrument approach procedures were completely revised. This resulted in several amendments to PANS-OPS in 1971, 1972, 1979, and 1980. For the approach portion of the operation, the main change has been to replace the somewhat unrealistic concepts of absolute worst-paths and arbitrary clearances with concepts of probability.<sup>6</sup>

## 5.2 FAA Application of the OCP Methodology to a Redefinition of the Minimum Required VFR Heliport Airspace

It is the second line of OCP work that is of interest in our discussion. The FAA has undertaken a task to redefine the minimum VFR heliport airspace using a mathematical/analytical approach coupled with operational judgment rather than relying exclusively on operational judgment as is now done. The elements of the FAA approach can be described as a modified version of the OCP approach:

- (a) collection of data on actual VFR heliport approaches and departures using a variety of pilots and different types of helicopters;
- (b) study of the performance capabilities of various helicopters, of pilot performance, and of the nature of visual aids to visual approach and departures; and
- (c) mathematical/analytical study of the flight data.

Prior to the OCP work, precision approach/departure TERPS criteria were based on 3 standard deviations of navigation error plus additional protection based on operational judgment combined to provide a very simple computation of deviation from the desired path. Over a very long international use of this system, no known accident had occurred which was attributed to inadequate obstacle clearance criteria.<sup>7</sup> However, the need to develop criteria for

higher performance aircraft lead ICAO to develop criteria based on something less subjective than operational judgement.

During a visual approach to a heliport, navigational error is not a consideration. Historically, the minimum required VFR airspace was developed on the basis of operational judgment. This operational judgment is, therefore, an element of commonality between the minimum airspace required for precision approaches/departures and that required for visual approaches/departures.

Three things dictate the need to approach the issue of VFR heliport airspace from a mathematical/analytical point of view. First, there is a need to resolve the differences of opinion between FAA and industry on what minimum VFR heliport airspace is required. The exercise of operational judgment has led two groups of people to conclusions which appear to conflict. A mathematical/analytical approach may allow us to reach a consensus. Second, there is a need to consider the greater capabilities of newer rotorcraft and to afford these aircraft with some operational advantage if appropriate. Third, there is a need to address curved approaches and departure paths in a way that is both operationally safe and acceptable to the aviation community. Basing the definition of minimum required VFR heliport airspace, for VFR curved approach and departure paths, solely on operational judgment is not likely to achieve both objectives.

Thus, if we are to develop a more precise and scientifically valid method of developing obstacle clearance criteria for visual approach/departures, the OCP work can serve as a model for how one could proceed. It is this model that the FAA has started to use in its VFR heliport data collection effort.

In the OCP work, two aspects are of particular interest. These are the issues of a target level of safety and a collision risk model. The following sections provide an overview of these issues and discuss their application to redefining the minimum required VFR heliport airspace.

## 6.0 TARGET LEVEL OF SAFETY

### 6.1 Introduction to the Concept

There are risks inherent in all forms of transportation and, with those forms that allow greater speed, the problems to be addressed are more complex. Years of accident analysis and FAA/industry response have made aviation one of the safest ways to travel. In spite of this, aviation accidents still occur. Both the FAA and industry are motivated to make aviation as safe as humanly possible. However, safety improvement projects must be

technically and economically realistic if the aviation community is to allocate the resources needed to pursue them. In looking to continue improving aviation safety, the community needs to analyze and quantify existing levels of safety and the potential safety gains to be achieved. Regarding questions of safety, the concept of target levels of safety is a fundamental part of any mathematical/statistical approach to systems planning.<sup>8</sup>

## 6.2 Definition

In the context of this report, systems planning involves the design of future rotorcraft facilities and operating procedures. One must ensure the safety of the entire system, not just the individual parts. The target level of safety is the level of safety that the system is intended to achieve. If the FAA and industry are to maintain and improve upon existing safety levels, we must relate our system planning objectives to safety objectives. These safety objectives can then be used to assess potential system changes and their likely effect on safety.<sup>9</sup>

## 6.3 Historical Perspective<sup>10</sup>

In the late 1950's, the British Air Registration Board (ARB) offered the concept of a target level of safety during the approval process for the autoland system on the Trident aircraft. Based on an examination of 18 landing accidents world-wide, the ARB had concluded that the fatal accident rate for transport category aircraft was 1 in  $10^6$  landings. The Board did not want to introduce a new hazard with the approval of an autoland system. Thus, the ARB required that the failure rate of the autoland system should be no more than 1 in  $10^7$  landings. This may have been the first application of the concept of target level of safety on an aviation issue.

In late 1966, the North Atlantic System Planning Group (NAT/SPG) considered setting a target level of safety as part of a mathematical/statistical assessment of future separation standards for the North Atlantic. The Group agreed that the target level should be related to the fatal accident rate of civil jet aircraft, that it should be a fraction of the overall accident rate apportioned to en route collisions, and that it should include a safety improvement factor (in the range of 2 to 5). In the spring of 1967, after reviewing jet accident data, the NAT/SPG agreed to a target level of safety for any one separation standard (lateral, longitudinal, or vertical) in the range of 0.15 to 0.4 fatal accidents due to en route collisions in  $10^7$  flying hours.

Upon its initiation in 1971, the Review of the General Concept of Separation Panel (RGCSP) considered various methods for choosing a target level of safety. The Panel reasoned that the point at

which risk becomes unacceptable to the public could be determined by looking at the risks that are generally accepted during our daily lives. Among the various bases that the Panel considered were the fatality rates of public surface transportation (trains and buses), the weighted population mortality rates, and the mortality rates of various non-aviation occupations. They also reviewed historical air transport accident rates. (See Appendix E for elaboration on the various rates considered.) Based on this analysis, the Panel recommended a target level somewhat tighter than the level recommended by the NAT/SPG. This tighter target was not accepted.

In 1975 and 1976, the NAT/SPG refined its analysis of the target level of safety. The Panel based this new analysis on an experienced fatal jet accident rate of 10 in  $10^7$  flying hours. Based on an extrapolation of improving safety trends, the NAT/SPG recommended a target level of safety of 6.5 fatal accidents from all causes in  $10^7$  flying hours. The portion of this risk assigned to collision risk due to loss of separation was 0.2 fatal en route accidents in  $10^7$  flying hours for each separation standard (lateral, longitudinal, and vertical). This recommendation was accepted and is still in use. However, the RGCSP is deliberating whether this target level of safety should be tightened an order of magnitude to 0.2 fatal aircraft accidents in  $10^8$  flying hours.

#### 6.4 ILS Precision Approaches - Derivation and Application of a Target Level of Safety.

The OCP work was influenced heavily by the work of the British Civil Aviation Authority (see references CAA 77002 and CAA 88009). In the refinement of obstacle clearance criteria, the OCP was charged to take a series of 3 steps discussed earlier in section 5.1. In studying the Panel's work, however, it becomes apparent that the OCP followed a course of action involving 8 steps. The following is a simplified summary of those steps:

- (a) The choice of a unit for measurement of risk (e.g., accidents per 100,000 hours).
- (b) The choice of a target level of safety for the overall risk due to all causes (e.g., no more than x accidents per 100,000 hours).
- (c) The estimation of that proportion of the overall risk which will be allocated to the operations of interest: ILS fixed-wing precision approaches to runways (no more than 1 collision in 10 million approaches).

(d) The collection of "representative data" on aircraft displacement, both vertical and lateral, about the nominal flight path at various ranges during an ILS approach.

(e) The use of these data in developing a model giving the probability distributions of vertical and lateral displacement about the nominal path at various ranges during the approach.

(f) The determination that the displacements in the vertical and lateral dimensions could be considered to be independent of one another. Thus, the 2 distributions were combined at each range to produce a 2 dimensional probability distribution characterized by isoprobability contours.

(g) The selection of particular isoprobability curves based on the target level of safety from (c) above. (For the distribution seen in the data on precision approaches, the 1 in 10<sup>7</sup> target level of safety equates to 6 sigma.)

(h) The development of plane surfaces to approximate the isoprobability curves of (g). (The use of plane surfaces is a simplification to avoid the complexity of dealing with complex curvilinear surfaces.)

In studying these steps, it is readily apparent that assumptions and decisions made during the multi-year OCP project were tailored to a situation (fixed-wing precision approaches to runways using instrument landing systems (ILS)) that differs dramatically from the one of current interest (visual heliport approaches and departures). In our VFR heliport efforts to date, the FAA has been following the 3-step approach of section 5.2. In hindsight, however, it would be more appropriate to follow the 8-step approach of section 6.4. Although the agency has come to this conclusion, the FAA has not yet taken several necessary steps in response. For example:

FAA has not considered specifically the issue of target level of safety: "How safe do we want to be?". (Steps (a), (b), and (c) of section 6.4 haven't been done.) These steps must be completed before a specific isoprobability curve can be selected (step (g)).

Collection of data (Step (d)) has been started but there is some discussion as to whether the data collected is fully "representative". The data were collected at sea level during daylight in an environment with few obstacles. Opposing opinions have been voiced on this issue. Some have argued that the test pilots would fly a tighter distribution if they had the visual cue of the obstacles to serve as guidance. Others have argued that the test pilots were aware

of the test issues and that they flew as tight a distribution as possible. The presence of obstacles, they argue, would have told the pilots how much airspace was available and would have encouraged pilots to fly a looser distribution.

Data analysis (Step (e)) is in progress now. Preliminary analysis has shown that the distributions are generally beta rather than Gaussian. Beta distributions have smaller tails than Gaussian distributions, however, beta distributions are substantially more difficult and time consuming to analyze.

Remaining efforts (steps (f), (g), and (h)) will depend on the results of the data analysis (step (e)).

Data analysis to date makes it clear that it is not appropriate to mimic blindly the work of the ICAO OCP. More specifically, it is not appropriate to base the redefinition of the VFR heliport airspace on the 6 sigma isoprobability curves of our VFR heliport approach and departure data. The OCP chose this 6 sigma value after much data analysis and careful consideration. Initially, this same 6 sigma value was chosen hastily for the VFR heliport scenario simply because no other standard was available. In retrospect, based on a better understanding of how the OCP selected this value, it is apparent that 6 sigma has no meaning in the context of the heliport flight data. A comparison should be made between the current VFR heliport airspace and the spread of the measured helicopter flight data. However, the particular sigma value to be used is not yet clear.

The various steps of the OCP methodology are appropriate for application to the redefinition of the minimum required VFR heliport airspace. However, the OCP's assumptions, decisions, and conclusions were based on an IFR precision approach scenario and flight data. Thus, if we are to use this methodology in a VFR heliport scenario, we must reconsider all of these assumptions, decisions, and conclusions. Most of this reconsideration has yet to be done.

## 7.0 COLLISION RISK MODEL

In all areas of aviation, it is not possible to guarantee absolute safety. Obstacle clearance criteria are based on the desire to achieve a suitable target level of safety. For the approach (and possible missed approach), ICAO has decided to express safety in terms of the number of collisions with an obstacle during a given number of approaches. The value chosen<sup>11</sup> and agreed upon internationally is no more than one collision in ten million approaches (1 in 10<sup>7</sup>).

In making a precision approach, aircraft will be distributed around the nominal path due to factors such as wind conditions, instrument performance, and flight technical error. It is assumed that the weather will prevent the pilot from seeing any obstacle(s). In order to permit safe operations, the airspace around the nominal path must be free of obstacles. The risk presented by an obstacle depends on two factors: the location of the obstacle relative to the nominal path of the aircraft and the extent to which the aircraft are likely to be spread about the nominal path at the range of the obstacle.

The ICAO Collision Risk Model (CRM) is a computer program that provides value estimates related to the risk of collision for individual obstacles and the total risk associated with the complete set of obstacles to be considered. This final value can then be compared with the target level of safety to help estimate whether the degree of risk associated with the particular operation is unacceptable. In the event that the risk is deemed unacceptable, the procedures specialist may use the CRM to study the relative effects of changes in any of the parameters involved. Examples include removing an obstacle or raising the glide path angle.<sup>12</sup>

During VFR heliport approaches and departures, the pilot can see the obstacles and use this visual cue to avoid them. (If there are any obstacles that can not be seen, this calls for proper lighting and marking and not for larger heliport airspace.) The ICAO CRM is not applicable to VFR operations since it is based on the assumption that the pilot can not see the obstacles. If we wish to evaluate the risk presented by multiple obstacles during a VFR heliport approach, a VFR CRM might be developed specifically for this purpose. A portion of a nonprecision approach is visual and the VFR heliport and the nonprecision approach heliport currently have the same minimum required airspace. Consequently, this model should be developed in a way that will allow it to be used to address the nonprecision approach heliport as well.

If it is possible to develop an acceptable visual/nonprecision approach heliport CRM, such a model would provide a method for dealing with a plethora of obstacles just outside the current minimum VFR heliport airspace (the "picket fence"). To develop such a CRM would require flight testing in an obstacle rich environment. Such "flight testing" is best done using a rotorcraft simulator with a very high quality visual scene and a dense urban environment. The simulator would allow this testing to be done safely, efficiently, and with great flexibility in the control of the obstacle environment.

## 8.0 CONCLUSIONS

- 8.1 The ICAO Obstacle Clearance Panel (OCP) work on precision approach TERPS can serve as a useful model in the development of a more precise and scientifically valid method of defining obstacle clearance criteria for VFR heliport approaches and departures. However, this model does not lend itself to a simple application for redefinition of the minimum required VFR heliport airspace. One must realize that the OCP work was a multi-year effort and that it went through a number of iterations before the results were accepted by the ICAO community. In addition, the precision approach TERPS are based on a number of carefully considered assumptions, a target level of safety (TLS), and a collision risk model (CRM). Both the TLS and the CRM were specifically tailored for fixed-wing runway operations. The specific target level of safety and all of the assumptions must be carefully reconsidered before they are applied to the issue of VFR heliport approaches and departures.
- 8.2 The ICAO CRM is not applicable to VFR operations since it is based on the assumption that the pilot can not see the obstacles. A VFR CRM should be developed on the basis of VFR rotorcraft flight data and rotorcraft simulator studies. Such a model would be useful in dealing with a plethora of obstacles (the "picket fence") just outside the limits of the minimum VFR airspace.
- 8.3 Over the years, a few rotorcraft accident have involved collisions with obstacles during heliport approaches and departures. To date, no accident analysis has addressed this issue with regard to accident rate or with regard to whether collisions with obstacles are taking place inside or outside the current VFR heliport airspace. Such an analysis is a necessary part of any effort to validate or modify the current heliport surfaces.
- 8.4 As a result of 2 significant reductions, the minimum required VFR heliport airspace currently required is a fraction of what was required in the early 1960's. While further reduction may be possible, any further reduction will require that a number of issues be considered very carefully. The most obvious of these is the issue of obstruction clearance criteria. However, also to be considered are a number of other issues:
- (a) infrastructure issues regarding the minimum airspace required for a VFR heliport and that required for a heliport with a nonprecision approach. (Currently, the airspace is the same for both heliports.)

(b) the trade off involved in any decrease in the minimum required VFR airspace. A decrease might allow additional heliports to be built in obstacle congested areas but it would decrease the limited FAR Part 77 protection afforded to all public heliports.

(c) public perceptions of safety where the public consists of the population of buildings adjacent to a heliport approach or departure.

(d) regulatory difficulties involved in making changes to FAR Part 77. Any decrease in the minimum VFR heliport airspace is likely to be permanent.

(e) heliport lighting as it affects airspace consumption during VFR heliport approaches and departures at night.

## 9.0 RECOMMENDATIONS

9.1 In pursuing the validation/modification of the minimum VFR heliport airspace, the FAA should do the following:

(a) Conduct an accident analysis of rotorcraft collisions with obstacles during heliport approaches and departures.

(b) Develop a consensus with the rotorcraft community on the issue of a target level of safety for rotorcraft operations and on the allocation of total risk among the various phases of flight.

(c) Develop a mathematical/statistical approach to assist in redefining the minimum required VFR heliport airspace based on flight data and using the ICAO Obstacle Clearance Panel (OCP) work as a model.

9.2 Using the approach discussed in 9.1 (c), the FAA should define the minimum required airspace for curved approaches and departures at VFR heliports. This airspace should be defined in a way that permits the approval of a nonprecision approach at the heliport with curved approach and/or departure paths.

9.3 The FAA should develop a visual/nonprecision approach collision risk model (CRM) for application to the heliports in obstacle areas. Using the VFR CRM, the FAA should address the issue of when a plethora of obstacles (the so called "picket fence") just outside the minimum VFR heliport airspace constitutes a hazard during an approach or departure.

## 10.0 EPILOGUE

10.1 Taking into consideration the recommendations of this report, the FAA has decided to take the following actions subject to limitations of funding and personnel:

(a) Conduct an accident analysis of rotorcraft collisions with obstacles during heliport approaches and departures.

(b) Consult with the rotorcraft community on the issue of a target level of safety for rotorcraft operations and on the allocation of total risk among the various phases of flight.

(c) Develop a mathematical/statistical approach to assist in redefining the minimum required VFR heliport airspace based on flight data and using the ICAO Obstacle Clearance Panel (OCP) work as a model.

(d) Using the approach discussed in 10.0 (c), define the minimum required airspace for curved approaches and departures at VFR heliports.

10.2 The FAA has decided not to pursue the development of a visual/nonprecision approach collision risk model at this time.

#### APPENDIX A. FOOTNOTES

<sup>1</sup>FAA, AC 150/5390-2 Heliport Design, (Washington, D.C.: Government Printing Office, 1988), p. 3.

<sup>2</sup>Discussion with Luigi Iori, Office of Airport Standards, Design and Operations Criteria Division, April 1988.

<sup>3</sup>ICAO, Procedures for Air Navigation Services - Aircraft Operations, (Montreal, 1980), Volume 1, pp. viii, x.

<sup>4</sup>R.D. Hunter, The Development of Obstacle Clearance Criteria for ILS Operations at Civil Airports, (London: Civil Aviation Authority, 1980), p. 2.

<sup>5</sup>ICAO, Obstacle Clearance Panel First Meeting Report, (Montreal, 1968), p. 1-1.

<sup>6</sup>P. Brooker and T. Ingham, Target Levels of Safety for Controlled Airspace, (London: Civil Aviation Authority, 1977), p. 9.

<sup>7</sup>ICAO, Obstacle Clearance Panel First Meeting Report, (Montreal, 1968), p. 1-3.

<sup>8</sup>P. Brooker and T. Ingham, Target Levels of Safety for Controlled Airspace, (London: Civil Aviation Authority, 1977), p. 2.

<sup>9</sup>Ibid.

<sup>10</sup>Victor Foose, "Application of Target Level of Safety to ATC and Aircraft System Failures," FAA briefing package, November 8, 1983.

<sup>11</sup>ICAO, Manual on the Use of the Collision Risk Model (CRM) for ILS Operations, (Montreal, 1980), Part II, p. II-1-2.

<sup>12</sup>Ibid.

## APPENDIX B. ACRONYMS

AC	Advisory Circular
ANC	Air Navigation Commission (ICAO)
CAA	Civil Aviation Authority (UK)
CRM	Collision Risk Model
FAA	Federal Aviation Administration
FAR	Federal Aviation Regulation
FAR Part 77	Objects Affecting Navigable Airspace
FAR Part 626	Precursor to FAR Part 77
ICAO	International Civil Aviation Organization
IFR	Instrument Flight Rules
ILS	Instrument Landing System
NAT/SPG	North Atlantic System Planning Group
OCP	Obstacle Clearance Panel
PANS-OPS	Procedures for Air Navigation Services - Aircraft Operations
RGCSF	Review of the General Concept of Separation Panel
TERPS	Terminal Instrument Approach Procedures
TLS	Target Level of Safety
UK	United Kingdom
VFR	Visual Flight Rules

#### APPENDIX C, REFERENCES

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Federal Aviation Administration, Heliport Design, AC 150/5390-2, Washington D.C.: Government Printing Office, January 1988.

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ICAO, Procedures for Air Navigation Services - Aircraft Operations (PANS OPS), Volume I: Flight Procedures, ICAO Doc 8168-OPS/611, Vol. I, Montreal, August 1980.

McCarley, Ted O., "The Development of a Mathematical Model of Collision Risk for ILS Approach", Proceedings of the Conference of Safety Issues in Air Traffic Systems Planning and Design, 26-28 September 1983. Princeton, N.J.: Princeton University Press, 1984.

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Weiss, Rosanne M.; Wolf, Christopher J.; Harris, Maureen; and Triantos, James. Heliport Visual Approach and Departure Airspace Tests, FAA Report No. FAA/CT-TN87/40, Atlantic City, NJ. 1988.

Wolf, Christopher J., Analysis of Distributions of VFR Heliport Data, Draft FAA Report No. FAA/CT-TN88/44, Atlantic City, NJ., 1988.

#### APPENDIX D. FAR HELIPORT SURFACE DEFINITIONS

##### FAR 626, Heliport Surfaces, Adopted 15 July 1961

626.13 (a)(7) Heliport conical surface. A heliport conical surface is a surface sloping upward and outward to an altitude of 500 feet above the established heliport elevation at a ratio of 1 to 20, beginning at the heliport elevation on the perimeter of a circle of 500 foot radius centered on the heliport reference point.

626.3 (o) "Heliport reference point" means a point selected by the Agency as the approximate center of the heliport.

##### FAR 77, Heliport Surfaces, Adopted 19 October 1962

77.29 Heliport imaginary surfaces. A heliport conical surface is a surface sloping upward and outward to an altitude of 500 feet above the established heliport elevation at a ratio of 1 to 8, beginning at the heliport elevation on the perimeter of a circle or circles of 200-foot radius centered on each helipad.

##### FAR 77, Heliport Surfaces, Adopted 3 February 1965 (Still current at this time)

##### 77.29 Airport imaginary surfaces for heliports.

(a) Heliport primary surface. The area of the primary surface coincides in size and shape with the designated takeoff and landing area of a heliport. This surface is a horizontal plane at the elevation of the established heliport elevation.

(b) Heliport approach surface. The approach surface begins at each end of the heliport primary surface with the same width as the primary surface, and extends outward and upward for a horizontal distance of 4,000 feet where its width is 500 feet. The slope of the approach surface is 8 to 1 for civil heliports and 10 to 1 for military heliports.

(c) Heliport transitional surfaces. These surfaces extend outward and upward from the lateral boundaries of the heliport primary surface and from the approach surfaces at a slope of 2 to 1 for a distance of 250 feet measured horizontally from the centerline of the primary and approach surfaces.

APPENDIX E. VARIOUS BASES CONSIDERED  
FOR SELECTION OF A TARGET LEVEL OF SAFETY

In the early 1970's, the Review of the General Concept of Separation Panel (RGCSF) considered various bases for the derivation of a target level of safety. This consideration led to the following comparisons:

If air transport category aircraft are to be as safe as public surface transportation (trains and buses), which had fatality rates of 0.15 and 0.2 (respectively) in  $10^8$  passenger miles, then the target level of safety would be:

0.65 - 0.7 fatal aircraft accidents in  $10^7$  flying hours.

If the air transport category aircraft accident rate is to be compared with weighted mortality rates, which were approximately 11 in 1,000 per year for the whole population and 6 in 1,000 per year for the age group 30-65, then the target level of safety would be:

3.5 - 6.5 fatal aircraft accidents in  $10^7$  flying hours.

If the aircrew occupational risk is to be compared with selected other occupations, which had fatality rates between 5 and 14 deaths in  $10^8$  hours worked, then the target level of safety would be:

1.5 - 4.2 fatal aircraft accidents in  $10^7$  flying hours.

If the target level of safety is to be determined on the basis of historical air transport category aircraft accident rates, with a target of improvement, the the target would be:

2.9 - 5.8 fatal aircraft accidents in  $10^7$  flying hours (based on jet aircraft data, 1967-1971, with an improvement factor of 2 to 4 assumed).

5.6 - 14 fatal aircraft accidents in  $10^7$  flying hours (based on jet aircraft data, 1968-1972, with an improvement factor of 2 to 5 assumed).